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Knowledge Engineering Enabling Knowledge Management

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ABSTRACT

Knowledge is context dependent. This paper presents the experiences of a knowledge engineer who worked with today's Information-Age United States Army attempting to clarify thinking at a strategic level. Within that context, the paper gives examples of how a knowledge engineer can provide better context-oriented communications to clients, thus enabling knowledge management and the opportunity to leverage knowledge for strategic advantage.

INTRODUCTION

Knowledge management is a business administration area of research that began in the early 1990s. Its goal is to leverage knowledge as a key asset and resource in modern organizations. Initially, knowledge management focused information technology resources on the development of groupware, document repositories, and portals. Regrettably, this served to obscure for many people the difference between information and knowledge. The United States Army (US Army) developed its portal calling it *Army Knowledge On-line*. Merely giving a soldier access to a repository of information does not necessarily provide the soldier with the *know how* (i.e., knowledge) to use the information.

Even the "deep thinkers" who support the US Army do not always have a clear grasp of the difference between information and knowledge. For example, a RAND Arroyo Center monograph (Darilek et al., 2001) prepared for the US Army stipulates in its opening pages a characterization of "information as knowledge." The publication states that it draws on concepts in *Joint Vision 2010* and their further development in *Joint Vision 2020* to frame the report's "exploration of the value of information or, more specifically, of information superiority, which is what the US Army says, in *Army Vision 2010*, its seeks to achieve." According to the monograph, knowledge is different from information only in quality and value. The authors come full circle summarizing that "knowledge consists of relevant and useful information." The problem with this is not academic semantics; it is the influence that these words might have on knowledge or information metrics. The RAND publication sought to develop a "limited set of Information-Age MOEs [Measurements of Effectiveness] in an attempt to spark the development of many more such measures which will be needed in the future to quantify the value of information in military operations, including combat."

In Kosovo, the US Army as part of a NATO [North Atlantic Treaty Organization] force was involved in a joint and multinational military operation. This operation exposed problems with the technological systems that allowed NATO to have almost absolute information superiority over the battlefield. In fact NATO's battlespace awareness was manipulated by the Serbian armed forces more often than expected (Thomas, 2000). The technological systems provided information, but the human link in the NATO analytic process had difficulty putting this information into action. Information superiority is critical to battlespace efficacy, but without an ability to contribute to knowledge and the management of that knowledge, it quickly loses both its operational and strategic importance.

TERMINOLOGY IS IMPORTANT

A practical definition of knowledge management is a framework and tool set for improving an organization's knowledge infrastructure, aimed at getting the right knowledge to the right people in the right form at the right time (Schreiber et al., 2002). A critical part of the framework is terminology because it enables context-oriented communication. Failing to understand the basic terminology or failing to use the terminology as precisely as we should, produces two detrimental effects: (1) It hampers a common, shared reality for the community of users, and (2) It impedes an organization's ability to link knowledge management to strategic and competitive advantage. As information technology professionals, often we do not emphasize the importance of terminology to our clients. Not only must we understand the meanings of the terms used in our client's environment, but also our clients must understand the terms that we use, specifically the distinction between information and knowledge. A good way to secure an understanding is to provide an example that is in the client's context.

Using the US Army environment as our client's context, a simple example of information that every soldier can easily recognize is a map. The map organizes the data (i.e., representations of towns, roads, rivers, hills, etc.) into relationships of area, distance, and direction. We want the client to understand that information can have a range of quality, and it can certainly be either relevant or irrelevant at any particular point in time, but it is still not knowledge. Soldiers can easily understand that the quality and relevance of a map (i.e., information) depends on various factors. A map that has a scale of 1:50000 does not present the same detail (i.e., quality) of information to a soldier as a map that has a scale of 1:10000. A map of Frankfurt, Germany is not as relevant as a map of Baghdad, Iraq to a soldier in Baghdad trying to get to Baghdad International Airport. Even a map of the highest quality and the most relevance is not knowledge, nor does it give any knowledge to someone who does not know how to read it, and put it to use for a specific purpose. *Knowledge* is information in action (Smith & Farquhar, 2000). But there is more.

Suppose a soldier is in Baghdad with a quality, relevant map of the area and needs to know how long it will take to walk to Baghdad International Airport from his current position. The map gives distance, and the speed that the soldier walks is known from personal experience. If the soldier knows from the "math world" that distance = speed ´ time and can solve for time given distance from the "map world" and walking speed from the "soldier's world", then the soldier has knowledge – information in action. The soldier can answer the posed question. This simple example reifies to a US Army client the differences between the concepts of information and knowledge, and it makes it easier for them to explain the context of their environment in those terms. However, it also reveals to the client subtleties in the knowledge definition: (1) the existence of an entity capable of putting information into action, (2) the use of information from different "worlds" (i.e., domains) to construct knowledge, (3) the sense of purpose in solving a problem, and (4) the production of new information (the solution to the problem).

HUMANS ARE NOT ALONE

Until the last century, human beings were the sole holders of knowledge because they were the only entities capable of putting information into action. For thousands of years knowledge was passed from one human to another, otherwise, it was lost. Highly valued knowledge was often kept by a collection of humans (e.g., tribes, craftsmen, etc.) to increase the likelihood that the knowledge would survive over time by being passed onto the next generation. The written word became an attempt to capture and preserve knowledge from one generation to the next. However by attempting to put knowledge into writing, knowledge was reduced to information. Perhaps this is where the confusion about knowledge and information began. Nonetheless, a book by itself is incapable of putting the information that it holds into action solving a problem.

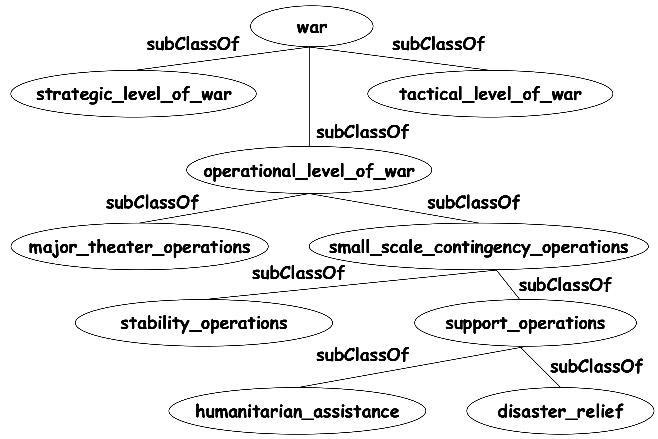
The human monopoly on knowledge started to erode early in the last century. In 1902, Mark Honeywell invented the thermostat, a device that used a sensing mechanism to gather temperature data from its environment, compared the data to the information of desired upper and lower bounds of temperatures for that environment, and took action to either turn on or off a furnace autonomously. By definition then, the thermostat had knowledge, albeit very limited and highly focused. By the end of the last century, computer programs called *intelligent agents* were demonstrating that they too were holders of knowledge. An intelligent agent is a knowledge-based software system that is capable of perceiving its environment, determining reasoned courses of action by interpreting perceptions, drawing inferences, and solving problems in that environment, and acting upon that environment to realize a set of goals or tasks for which it was designed (Russell & Norvig, 1995). So today, holders of knowledge are individuals (i.e., humans), organizations (i.e., human collectives), and some information systems (i.e., intelligent agents).

In the late 1970s, knowledge engineering was focused only on the development of information systems in which knowledge and reasoning play pivotal roles (i.e., knowledge-based systems). Today, knowledge engineering does more. It provides tools and techniques for thoroughly understanding the structures and processes used by knowledge workers. Knowledge engineers can help identify opportunities in organizations for the development, application, and distribution of knowledge resources (Schreiber et al., 2002). Knowledge engineering has turned from trying to extract knowledge from humans to a modeling activity. The focus of knowledge modeling is the conceptual structure of knowledge. The emphasis is on the real world situation in the workplace as well as the context of organizational problem solving. The concepts and relationships between concepts reflect the real world domain and are expressed in a vocabulary that is understood by people working in that domain. Rapid prototyping has been very popular in knowledge-based systems because it enables both human and machine learning from the modeling experience through feedback and knowledge refinement.

For the last eight years the Defense Advanced Research Projects Agency (DARPA) has supported research aimed at the establishment of large knowledge bases and the feasibility of large-scale reuse. The High Performance Knowledge Base (HPKB) program that ended in fall 1999 produced reusable knowledge repositories of concepts, relationships, and actions for crisis and battlefield reasoning at the tactical level of war. DARPA's Rapid Knowledge Formation (RKF) program built on HPKB's contributions seeking to enable senior military leaders to directly transfer their problem solving expertise at the operational and/or strategic levels of war to intelligent agents. In Fall 2000, knowledge engineers in the Center for Strategic Leadership at the United States Army War College (USAWC) joined forces with faculty and graduate students from the Learning Agent Laboratory at George Mason University to participate in DARPA's RKF program. USAWC was interested in an intelligent agent with a knowledge model for the determination of the center of gravity (COG) of an opposing force (Lopez et al., 2002), a very vexing problem for even senior military leaders.

The concept of a COG dates back to 1832, when the widow of a military strategist of the time, Carl von Clausewitz, published his tome that attempted to develop a logical theory about war. Clausewitz (1832) defined the COG of an opposing force as "the hub of all power and movement, on which everything depends. That is the point against which all our energies should be directed." Today, the Department of the Army (2001) defines the COG to be "those characteristics, capabilities or localities from which a military force derives its freedom of action, physical strength or will to fight." Regardless of the definition one selects, the determination of the COG requires a great deal of knowledge. It requires an entity capable of putting information into action (e.g., a senior military leader or intelligent agent). It uses information from different domains, for example the psychosocial domain (in particular, religion), the economic domain, the political domain and others. Its problem solving purpose is focused in the COG identification, and the identification made becomes new information for another process (i.e., directing all our energies against it).

Figure 1: Ontological Fragment.



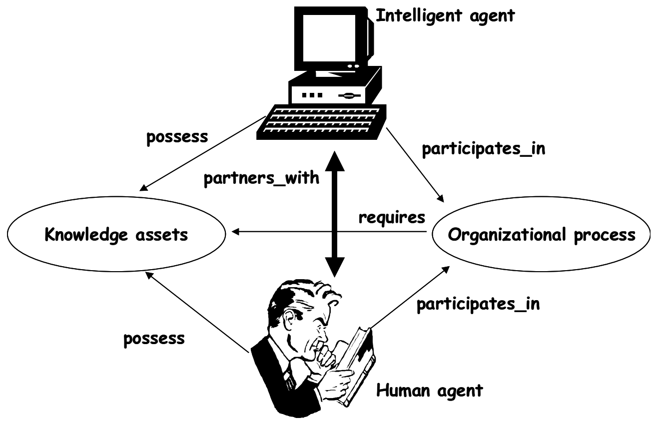
Terminology was critical to the success of the COG project at USAWC. Early-on knowledge engineers developed an ontology that would be the basis for future agent learning (Bowman et al., 2001). The graphical techniques (See Figure 1) employed in the ontology development to help clarify the more tacit aspects of knowledge also encouraged context-oriented communication with US Army personnel who often did not have a background in information technology. The ontology provided the vocabulary that would be common to senior military leaders and intelligent agents. The ontology described the different kinds of concepts and the relationships that exist between concepts. In sum, knowledge engineers provided the basis for a common shared reality for a community of users in the users' terminology.

Although DARPA's RFK program has ended, and the intelligent agent has been deployed (Tecuci et al., 2002), knowledge engineers have identified an opportunity for the US Army to further develop and distribute knowledge surrounding the COG concept. Based on Clausewitz's dictum that war is the continuation of policy by other means, knowledge engineers have built an ontological structure that uses the concept of strategy as a bridge between policy and operations in war (Lopez et al., 2003). For the US Army, this opens the door to linking knowledge management to strategic and competitive advantage. Furthermore, the knowledge engineers are suggesting that the distribution of the knowledge can be supported in a classified version of the Semantic Web.

PUTTING IT TOGETHER

There is little evidence that organizations are actually linking knowledge management to strategy (Zack, 2002). Zack claims that "the reason most organizations start with knowledge management rather than strategy, is that the people involved with strategy are not interacting at all with those doing knowledge management (nor do they understand much about knowledge management), and those doing knowledge management are not interacting with those doing strategy (nor do they understand much about the firm's strategy)." The US Army is not inclined to exemplify this type of reasoning because doing so can cost human lives and other precious resources. The USAWC project started as a knowledge engineering effort to understand strategy. The project did involve those who did not understand knowledge management and those who did not understand much about the strategic level of war. However, knowledge engineers were able to guide both groups to a successful end, thus setting the stage for knowledge management.

Figure 2: New Knowledge Object Model



Knowledge engineers and knowledge managers have different organizational roles (i.e., scope of work, range of options, etc.). Knowledge engineers build intelligent agents that must now become part of the object model of knowledge management. Figure 2 shows a version of the knowledge object model presented in Schreiber et al. (2002) with emphasis now being placed on the partnership between intelligent agent and human agent. Knowledge managers must orchestrate the use of all the elements of the knowledge object model to achieve strategic and competitive advantage.

In general, a knowledge management system has a community of human practitioners as its organizational base. This group shares a common area of expertise and seeks to solve common problems. The system has at its technological core: (1) A conceptual operational model of the organization which guides a systematic, transparent-to-the-user, knowledge acquisition process, (2) A collection of formalisms for representing the knowledge inside the computer system and a toolkit of mechanisms (i.e., multiple intelligent agents) for implementing autonomous reasoning, and (3) A delivery system that will provide the practitioner with the knowledge that is needed when it is needed (Preece et al., 2001). Knowledge engineering tools and techniques can directly support the technological core of the knowledge management system. Knowledge engineering might be able to position knowledge managers to make significant gains in organizational knowledge, but knowledge engineers cannot set the organizational priorities that will allow such advancements. That is the purview of the knowledge manager, so it is important that the knowledge manager understand the opportunities that knowledge engineers see. Ideally, when knowledge is gained in one area of the organization, the knowledge management system is intelligent enough about the organization (e.g., its goals and operations) to share the knowledge with another component of the organization that needs the knowledge but does not know that it needs it.

In order to advance professional knowledge of the strategic role of land power in joint and multinational operations, the Information-Age Army needs to capture, store, and deploy knowledge. This can be facilitated by the development of knowledge management systems that leverage the collective knowledge of soldiers from all levels in the Army, the organizational knowledge of Army doctrine and values, and the advancements in intelligent agent technology. The Information-Age Army can re-invent itself as the Knowledge-Age Army sharing and restructuring its professional knowledge with each new role it plays in joint and multinational land power operations. The Knowledge-Age Army will be able to connect soldiers who need knowledge with soldiers or intelligent agents who have it thereby bringing that knowledge to bear on solving important problems. The Knowledge-Age Army will be able to make its accumulated experience available to new soldiers or soldiers in new jobs so that they will not make the mistakes of the past and will become knowledge contributors faster. The Knowledge-Age Army will be an organization whose soldiers are knowledgeable about what their contemporaries are doing even on the other side of the world and all are sharing their knowledge in real-time to solve problems. The Knowledge-Age Army will have soldiers drawing on the latest research and development resources to understand how to improve the delivery of knowledge in a timely fashion. The way is clear. Knowledge management visionaries must now step forward and make the necessary commitments.

CONCLUSION

Few organizations today have a systematic process for capturing, storing, and deploying knowledge as distinct from doing the same for information (Preece et al., 2001). This is due in no small part because they fail to understand the distinction between information and knowledge. Knowledge engineers can help clarify these terms and others by concentrating on context-oriented communication with the client. Knowledge engineering methods provide means for structuring human knowledge as well as the wider organizational context in which it is used. This enables knowledge management. However, the decision to implement a knowledge management system still requires commitments from senior members of the organization.

Since knowledge is context dependent, this paper was framed using the context of the Information-Age Army. It presented the experiences of a knowledge engineer working on a USAWC project that emphasized to future US Army senior leaders and decision makers the importance of knowledge as opposed to information and created intelligent agents capable of determining the center of gravity of an opposing force. To adequately advance professional military knowledge of the strategic role of land power in joint and multinational operations, the US Army must look now to the development of intelligent agents as part of an overall knowledge management system that will capture, maintain, and continuously adapt the knowledge of soldiers in the art of war.

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